Design Detective: Analyzing Experimental Designs

Below are 10 scenarios (stories) each describing a scientific experiment. Your task is to analyze each experiment and identify the elements of a well designed experiment. Work carefully, though, because each experiment contains flaws in the experimental design! Part of your task is to point out the design flaws and to suggest improvements. Use the following steps as guidelines for evaluating each scenario.

1. Read the scenario carefully.

2. Begin by identifying the major components of the experiment. Watch for any flaws in the design of each experiment. Use the following outline format to get you started:
   Independent Variable:
   Dependent Variable:
   Constants:
   Control Group:
   Repeated Trials:
   Hypothesis:

3. Draw an "Experimental Design Diagram" for the experiment being described. Complete the diagram using the following steps:
   - Identify the **independent variable** in the scenario.
   - List the different **levels/amount of the independent variable.**
   - Identify the **dependent variable.**
   - List the **number of repeated trials** for each level of the independent variable.
   - List the **constants** in the experiment.
   - Identify the **control group** in the experiment (if present).

4. Identify the hypothesis for the experiment. Write the hypothesis using the following format:
   a) I predict..... because.....
   b) If my prediction is correct, the results I expect to see are...

5. Write a title for the experiment. Remember that a title includes:
   - the subject being tested
   - the independent variable
   - the dependent variable (outcome being observed)

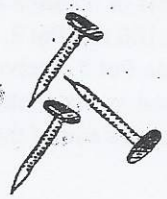
6. Below the Experimental Design Diagram, state two or more ways to improve the experiment described in the scenario. Watch for typical design flaws such as:
   - no control group
   - poorly defined constants
   - insufficient number of trials
   - limited number and type of dependent variables
   - insufficient time span and frequency of measurements
   - inappropriate use of animals

Scenario 1:
Compost and Bean Plants

After studying about recycling, members of Miguel's biology class investigated the effect of various recycled products on plant growth. Miguel's lab group compared the effect of different aged grass compost on bean plants. Because decomposition is necessary for release of nutrients, the group hypothesized that older grass compost would produce taller bean plants. Three flats containing the same species of bean plants (25 plants/flat) were grown for 5 days. The plants were then fertilized with compost as follows: (a) Flat A: 450 grams of two-month-old compost, (b) Flat B: 450 grams of four-month-old compost, (c) Flat C: 450 grams of six-month-old compost, and (d) Flat D: 0 grams of compost. The flats of beans were planted in the same type of soil. The plants received the same amount of sunlight and water each day. At the end of 30 days the group recorded the height of the plants in centimeters.

Scenario 2:
Metals and Rusting Iron

In chemistry class, Allen determined the effectiveness of various metals in releasing hydrogen gas from hydrochloric acid. Several weeks later, Allen read that a utilities company was burying lead next to iron pipes to prevent rusting. Allen hypothesized that less rusting would occur with the more active metals. He placed the following into separate beakers of water: (a) 1 iron nail only, (b) 1 iron nail wrapped with an aluminum strip, (c) 1 iron nail wrapped with a magnesium strip, (d) 1 iron nail wrapped with a lead strip. He used the same amount of water equal amounts (mass) of the metals, and the same type of iron nails. At the end of 5 days, he rated the amount of rusting as small, moderate, or large. He also recorded the color of the water since color is a critical clue for chemical reactions.



Scenario 3:
Perfumes and Bees' Behavior

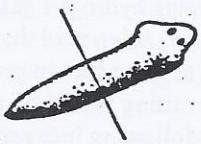
Maria read that certain perfume esters (chemicals) would agitate bees. Because perfume formulas are secret, the ingredients are never included on the label. Maria decided to determine whether any bee-agitating esters were present in four different perfumes by observing the bees' behavior. She placed a saucer containing 10 ml of the first perfume 3 meters from a bee hive. She recorded the time required for the bees to emerge and made observations on their behavior. After a 30-minute recovery period, she tested the second, third, and fourth perfumes. All experiments were conducted on the same day when the weather conditions were similar; that is air, temperature, and wind.

Scenario 4:
Fossils and Cliff Depth

Lucrecia observed different kinds of fossils were present in a cliff behind her house. She wondered why if different amounts of each type of fossil occurred at different depths of the bank. She marked the bank at five portions: 5, 10, 15, 20, and 25 meters from the surface. She removed 1 bucket of soil from each of the positions and determined the kind and number of fossils in each sample.

Scenario 5:
Aloe vera and Planaria

Jackie read that *Aloe vera* promoted healing of burned tissue. She decided to investigate the effect of varying amounts of *Aloe vera* on the regeneration of planaria (a fresh water flatworm). (Regeneration is the process of growing back a lost body part.) Jackie bisected (cut in half) five planaria to obtain 10 parts (5 heads and 5 tails) for each experimental group. She applied concentrations of 0%, 10%, 20%, and 30% *Aloe vera* to the groups. Fifteen milliliters of *Aloe vera* solutions were applied. All planaria were maintained in a growth chamber with identical food, temperature, and humidity. On Day 15, Jackie observed the regeneration of the planaria parts and categorized development as full, partial, or none.



Scenario 6:
Seed Germination

Ten seeds were planted in each of 5 pots found around the house that contained 500 grams of "Pete's Potting Soil." The pots were given the following amounts of distilled water each day for 40 days: Pot 1, 50 ml; Pot 2, 100 ml; Pot 3, 150 ml; Pot 4, 200 ml; and Pot 5, 250 ml. Because Pot 3 received the recommended amount of water, it was used as the control group. The height of each plant was measured at the end of the experiment.

Scenario 7:
Kindergarten Children and Colored Mashed Potatoes

Gloria wanted to find out if the color of food would affect whether kindergarten children would select it for lunch. She put food coloring into 4 identical bowls of mashed potatoes. The colors were red, green, yellow and blue. Each child chose a scoop of potatoes of the color of their choice. Gloria did this experiment using 100 students. She recorded the number of students that chose each color.

Scenario 8:
How Far Will the Carton Spurt Liquid?

Susie wondered if the height of a hole punched in the side of a quart-size milk carton would affect how far from the container a liquid would spurt when the carton was full of the liquid. She used 4 identical cartons and punched the same size hole in each. The hole was placed at a different height on one side of each of the containers. The height of the holes varied in increments of 5 cm, ranging from 5 cm to 20 cm from the base of the carton. She put her finger over the holes and filled the cartons to a height of 25 cm with a liquid. When each carton was filled to the proper level, she placed it in the sink and removed her finger. Susie measured how far away from the carton's base the liquid had squirted when it hit the bottom of the sink.

Scenario 9:
Plant Competition for Space

Maritza heard that plants compete for space. She decided to test this idea. She bought a mixture of flower seeds and some potting soil. Into each of 5 plastic cups she put the same amount of soil. In the first cup she planted 2 seeds, in the second cup she planted 4 seeds, in the third cup 8 seeds, and in the fourth cup she planted 16 seeds. In the last cup she planted 32 seeds. After 25 days, she determined which set of plants looked the best.

Scenario 10:
Insulation

Ester became interested in insulation while her parent's new house was being guilt. She decided to determine which insulation transferred the least heat. She filled each of 5 jars half-full with water. She sealed each jar with a plastic lid. Then she wrapped each jar with a different kind of insulation. She put the jars outside in the direct sunlight. Later, she measured the temperature of the water in each jar.